

Effectiveness of FRP in Reducing Corrosion in a Marine Environment



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**2009 US Army Corrosion Summit
Clearwater, FL**

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Pile Corrosion



Pile Corrosion



Courtesy - Alltrista





Outline



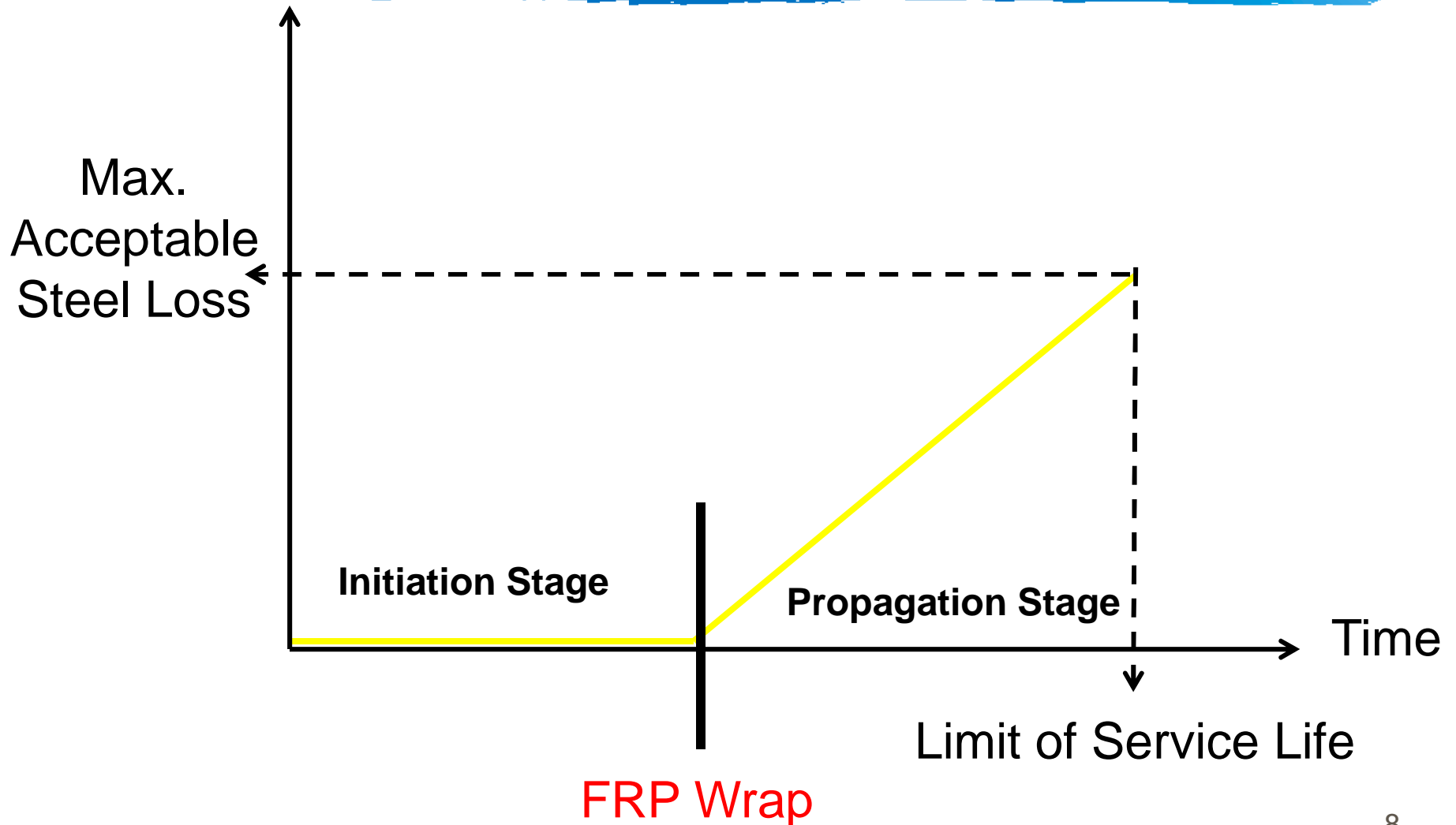
- Background
- Test Program
- Findings
- Field Applications
- Concluding Remarks
- Acknowledgements

Project Goals

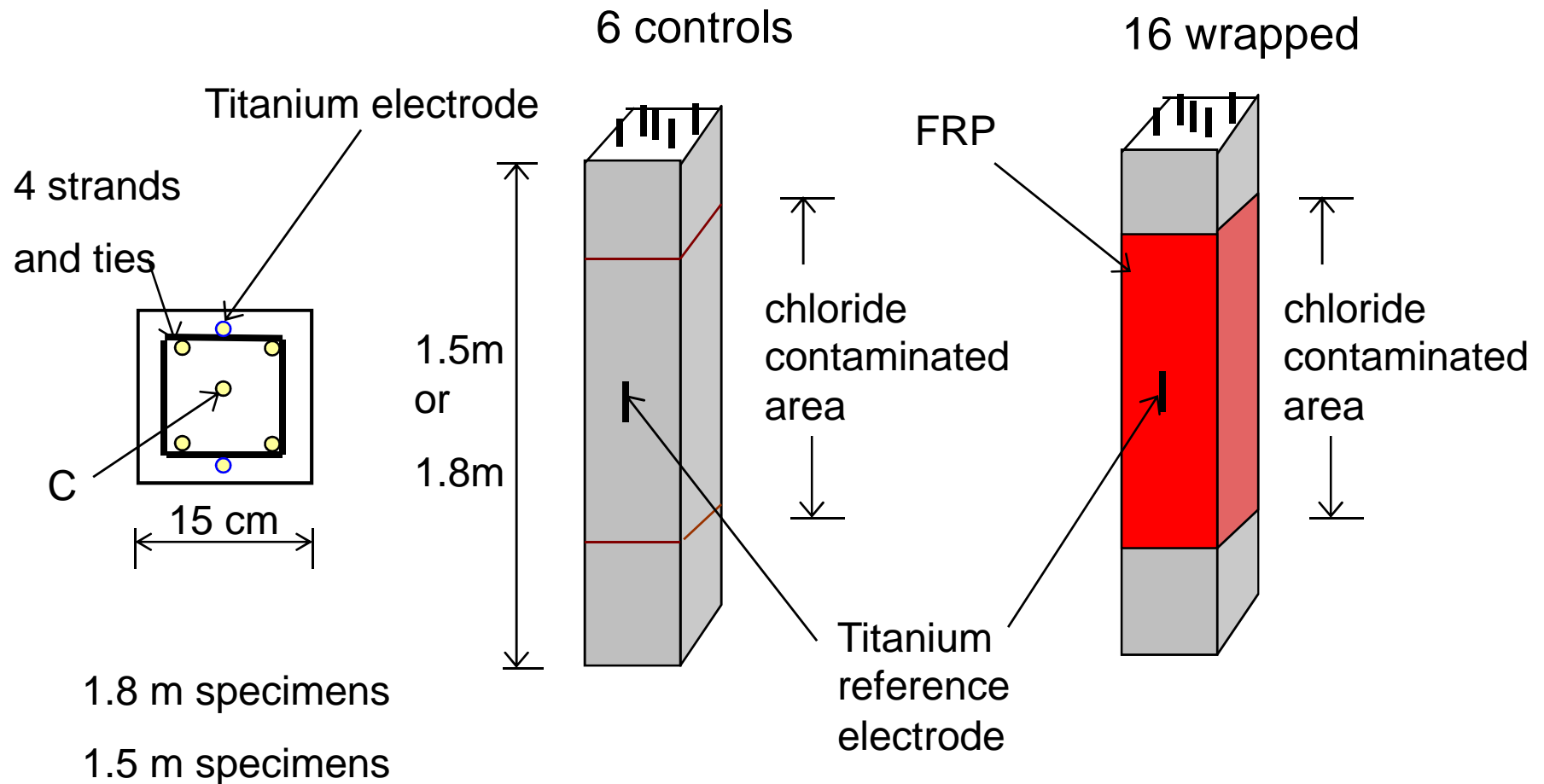


- How effective is FRP in mitigating corrosion?
- How important is the pre-wrap repair?
(Not covered)
- How feasible is it to conduct field repairs?

Tuutti's Corrosion Model



Test Specimen

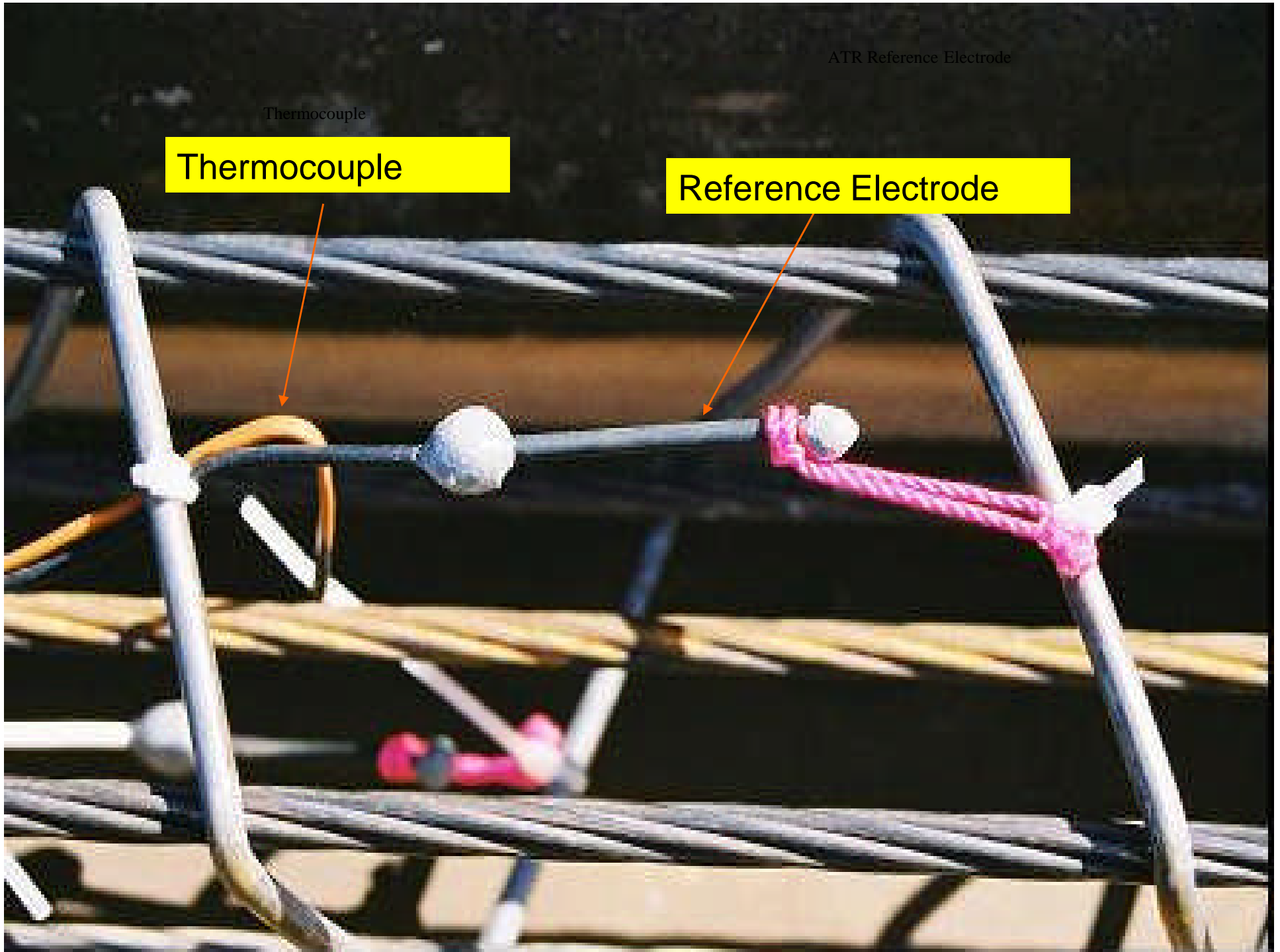


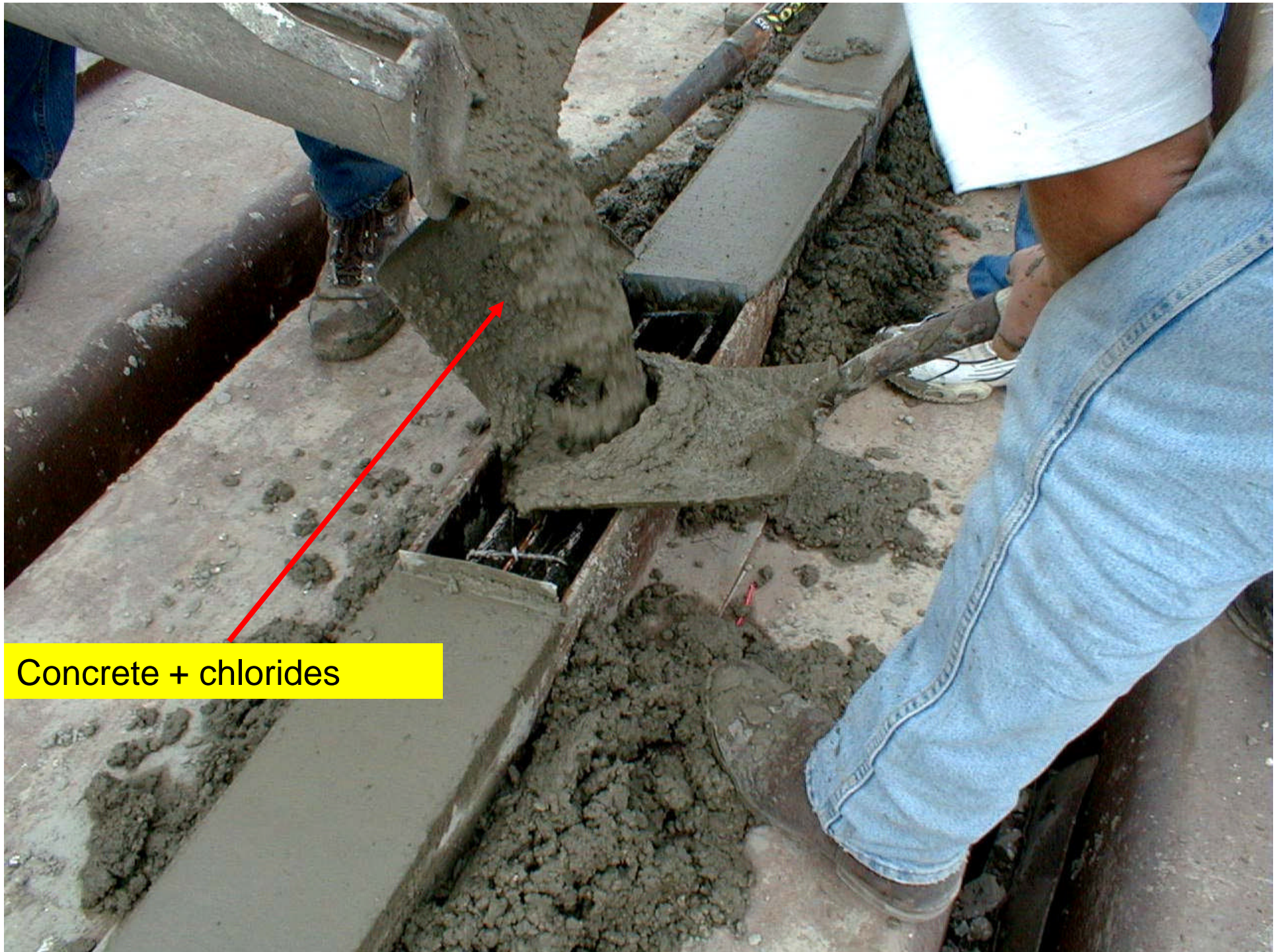
ATR Reference Electrode

Thermocouple

Thermocouple

Reference Electrode





Concrete + chlorides

FRP Wrapping



- 28 days
- Glass
 - 1, 2, 3, 4 layers
- Carbon
 - 1, 2, 3, 4 layers

Carbon Fiber Wrap



Glass Fiber Wrap



Ambient Exposure



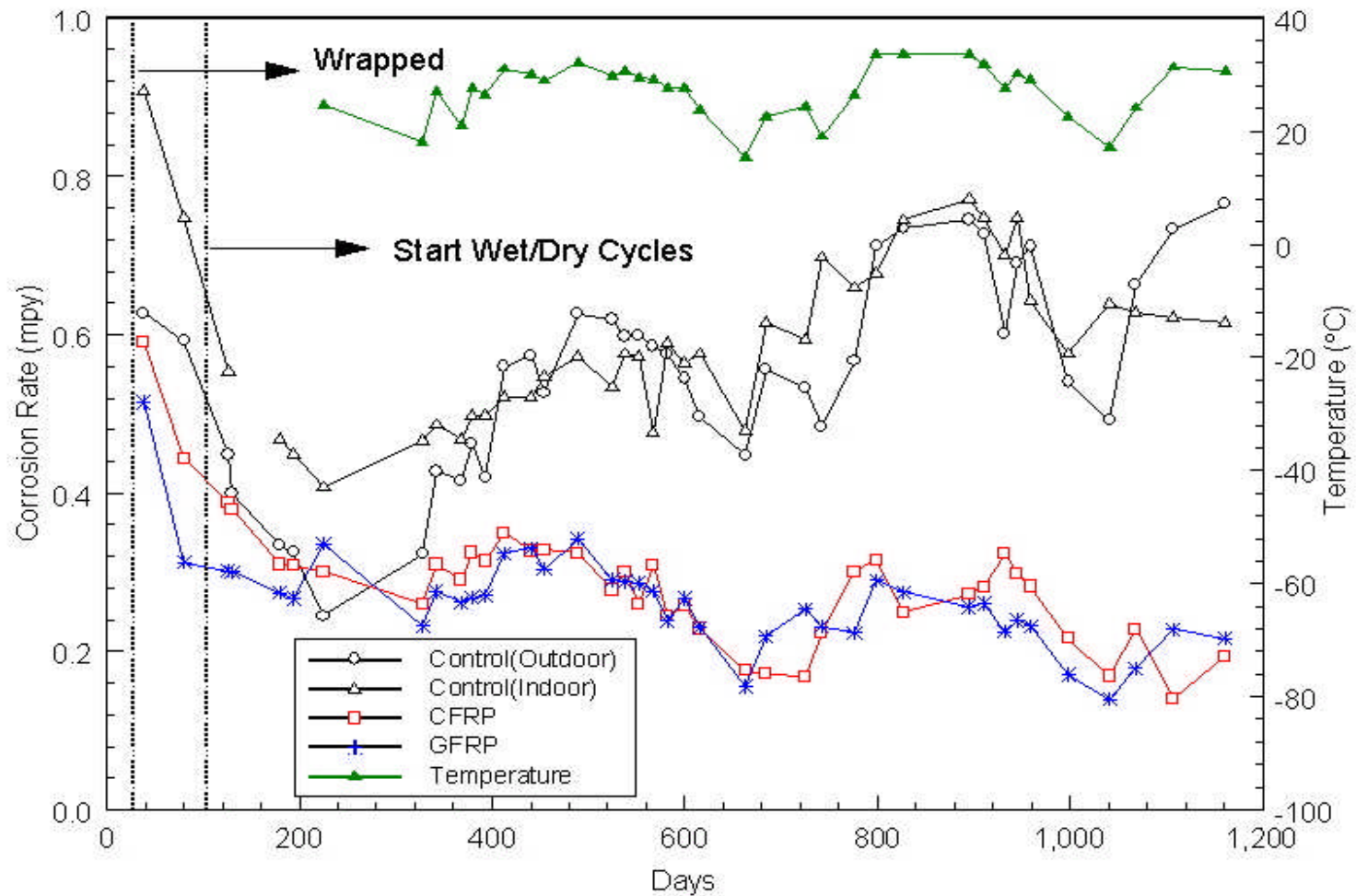
- 3.5% salt water
- Wet/dry cycles: every 6 hrs
- 1160 days (3 yrs 2 months)



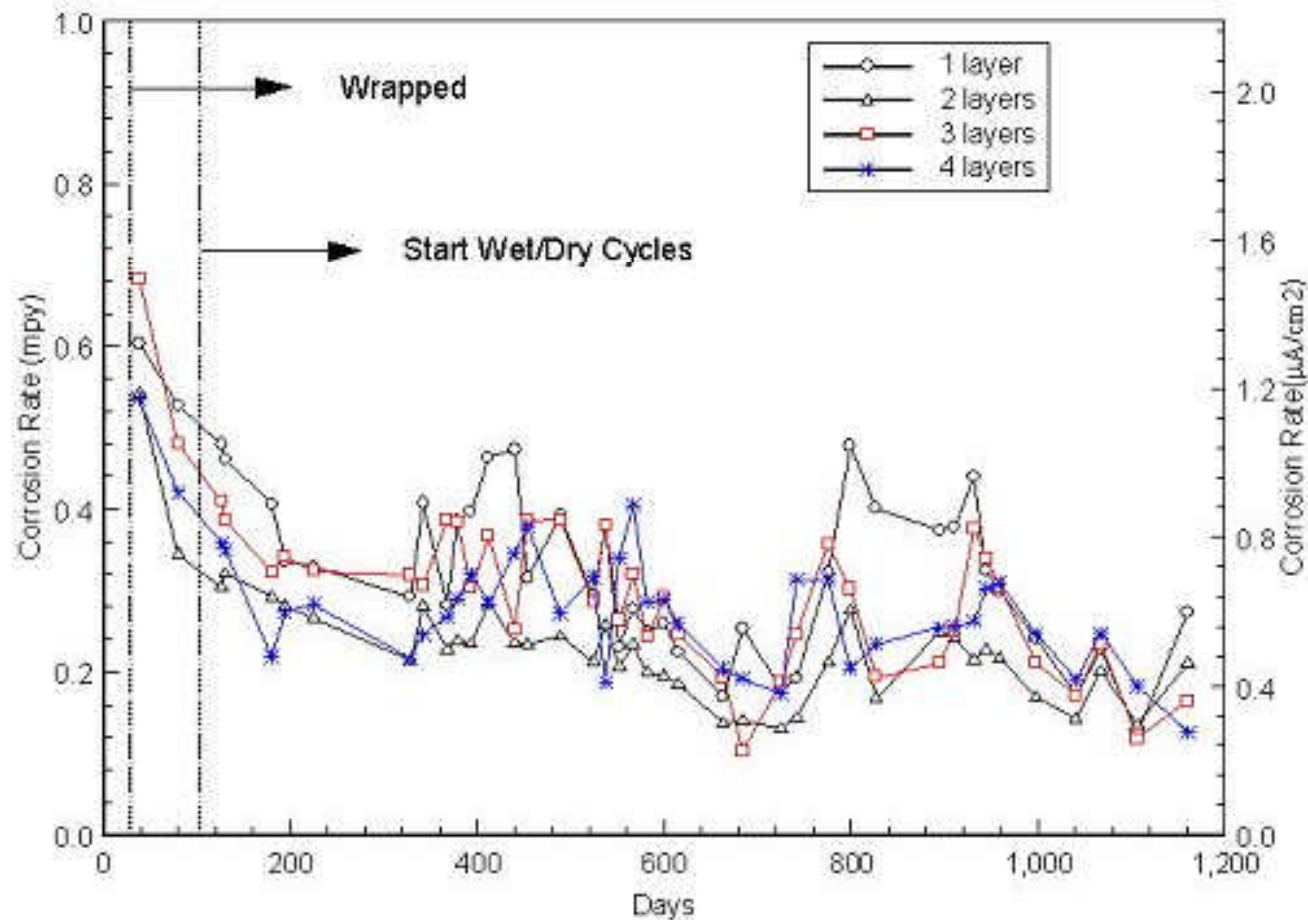
Controls vs Wrapped Specimens



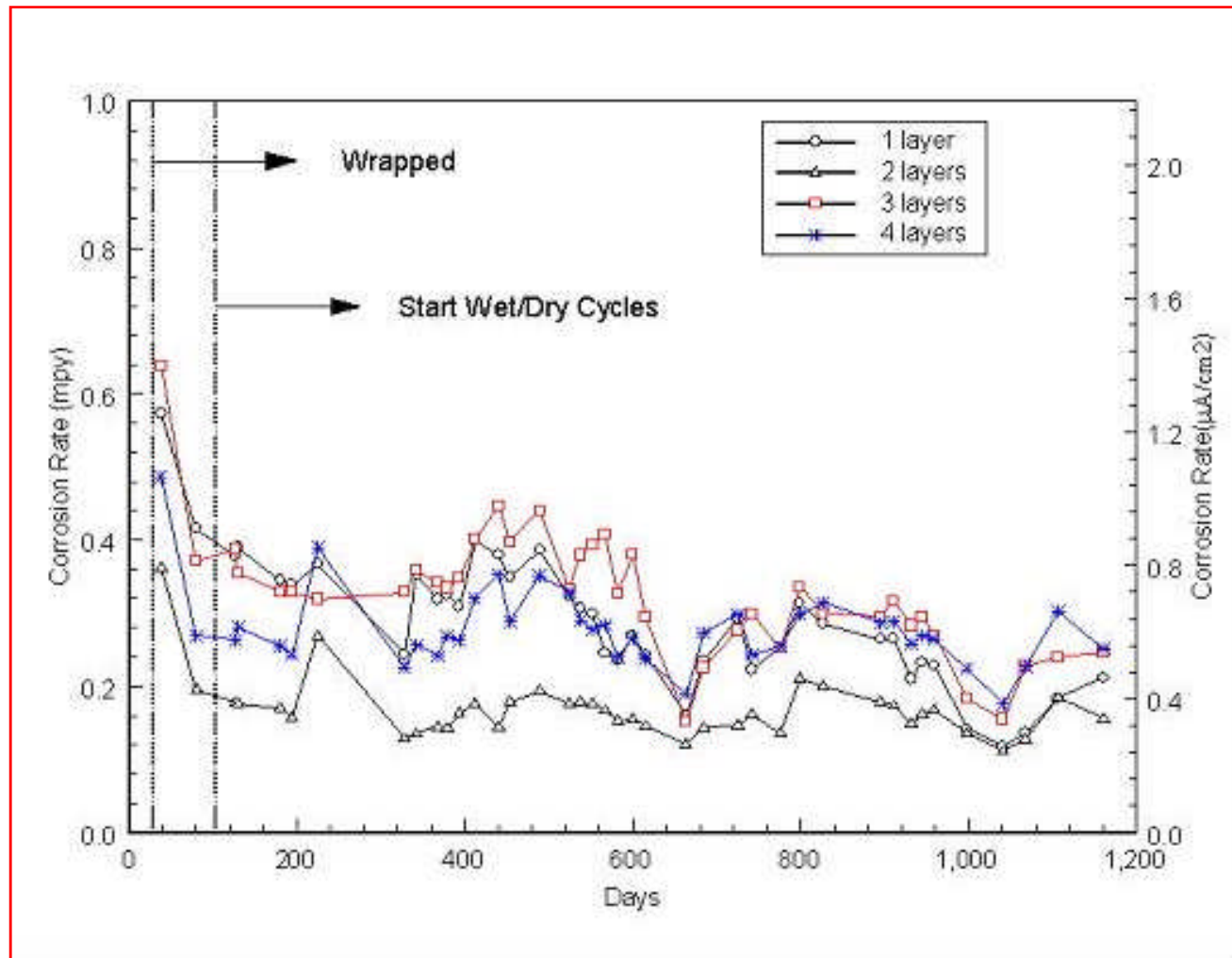
Effect on Corrosion Rate



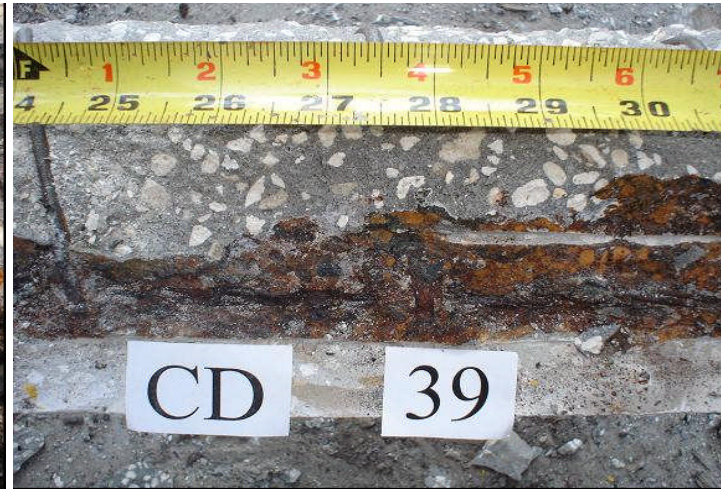
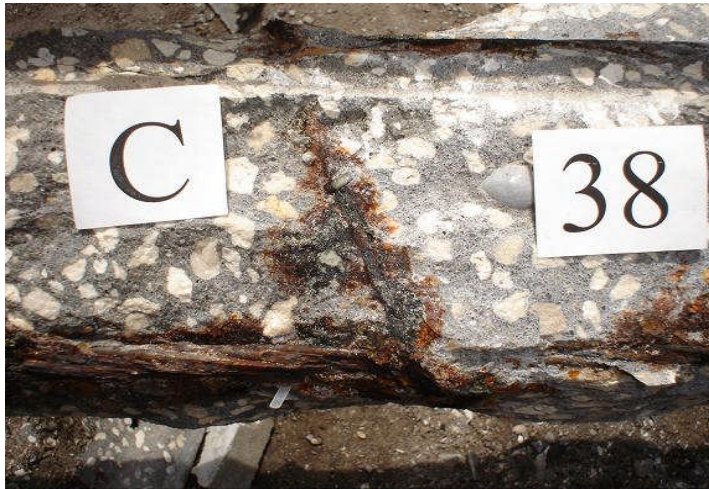
Role of Layers - CFRP



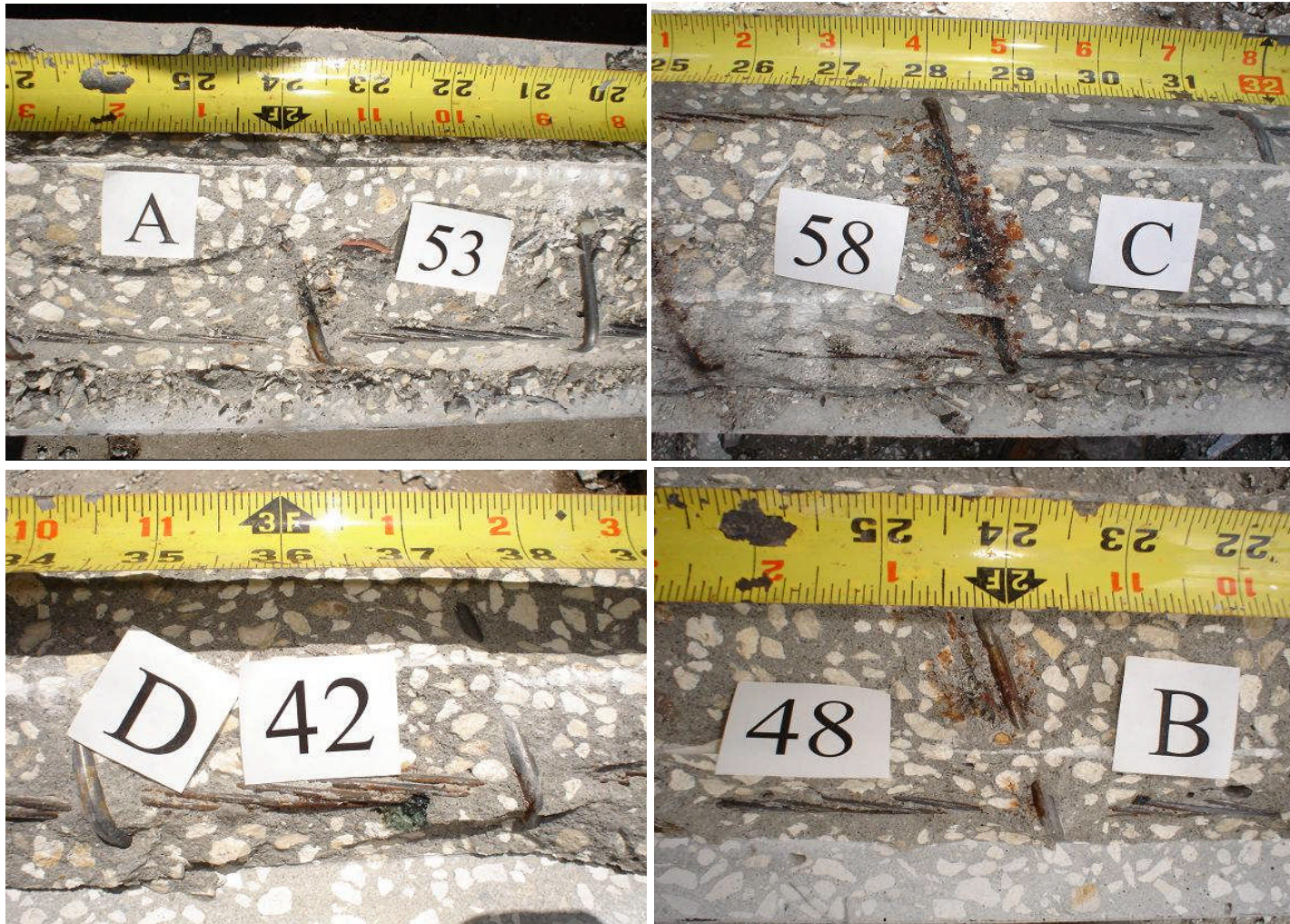
Role of Layers - GFRP



Unwrapped Controls



Wrapped Specimens



Retrieved Strands



Outdoor Control

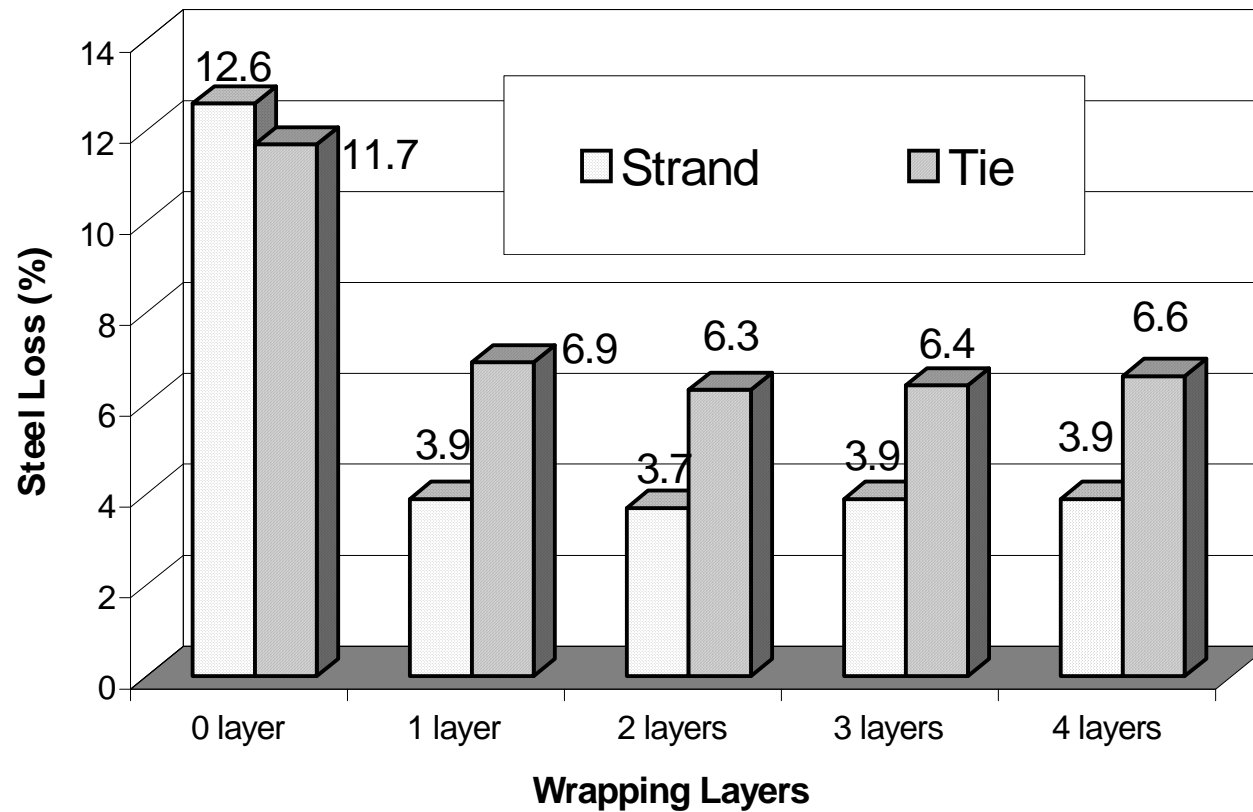
30 wire
breaks in
6 controls



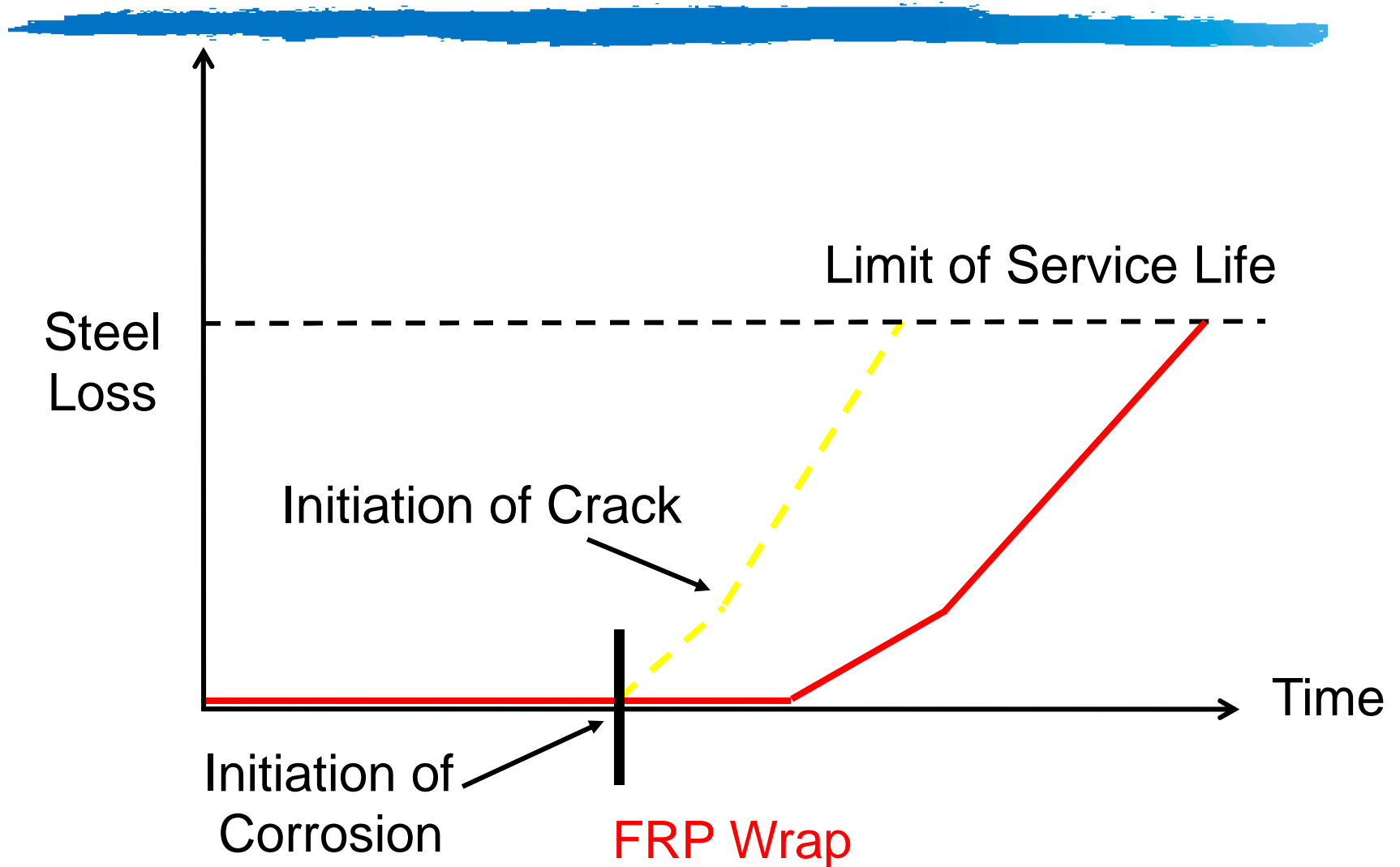
CFRP Wrapped

1 wire
break in
16 FRP
specimen

1/3rd Metal Loss in Wrapped Specimens



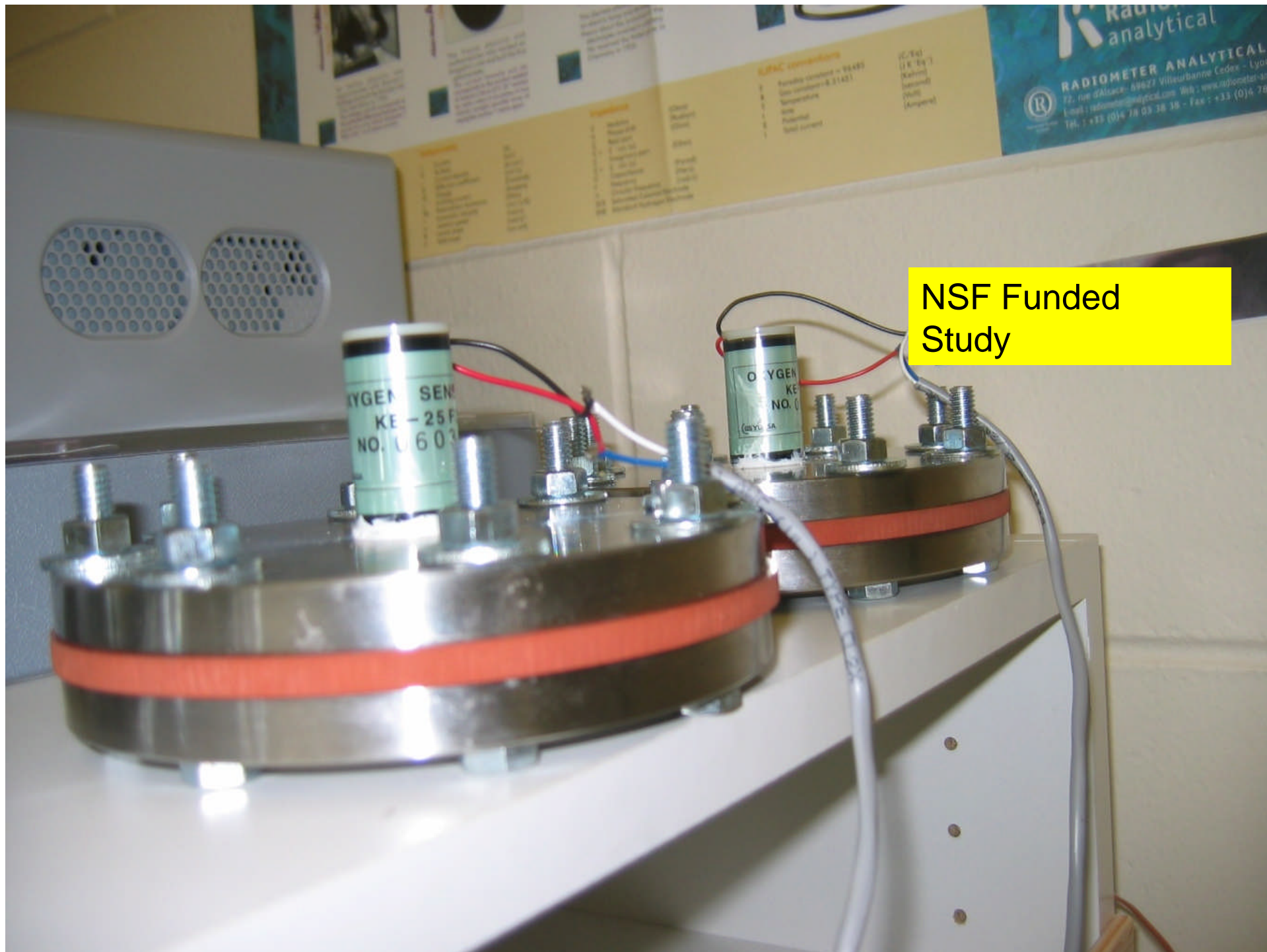
Implications



Why?

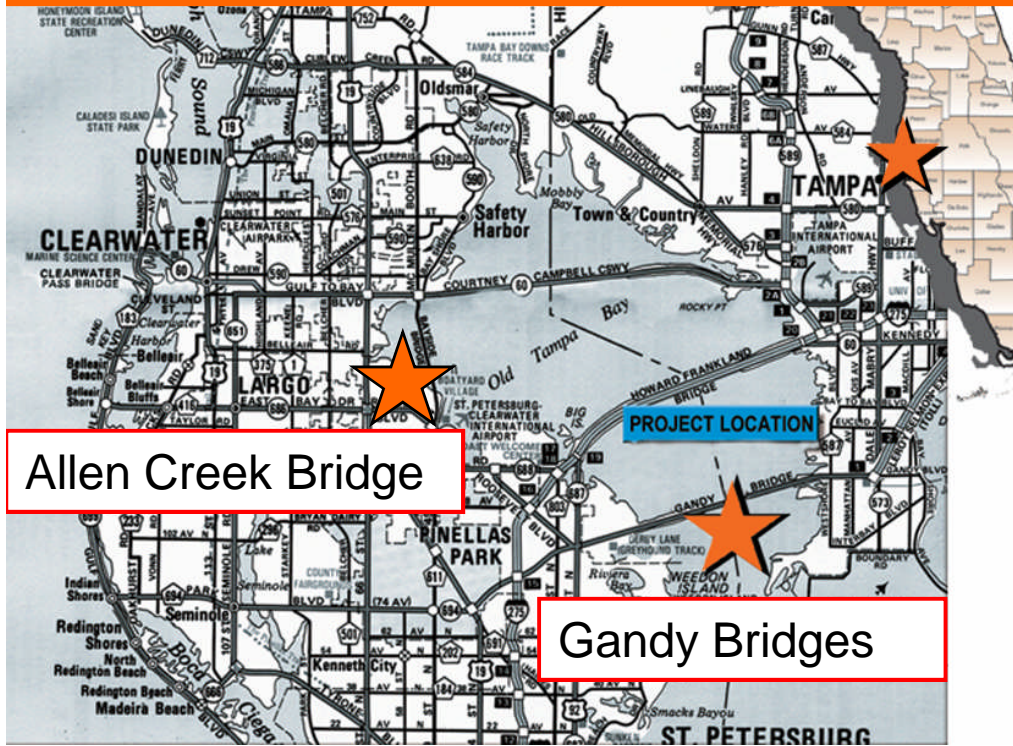


- Tests are underway to evaluate FRP's performance as a barrier
- If possible, we would like to evaluate coatings that could conceivably be used to improve FRP's performance

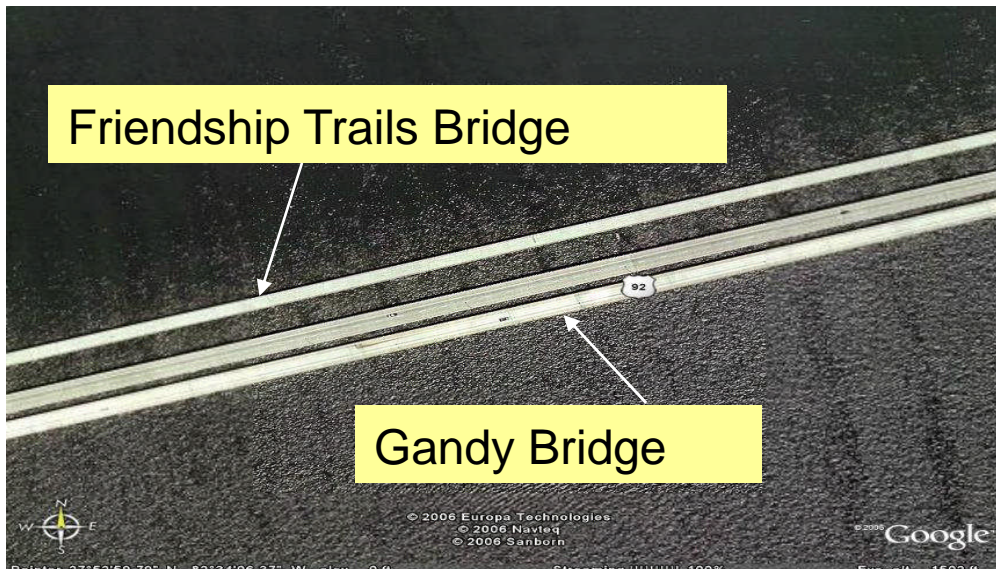


Field Validation

Field Demonstration Studies



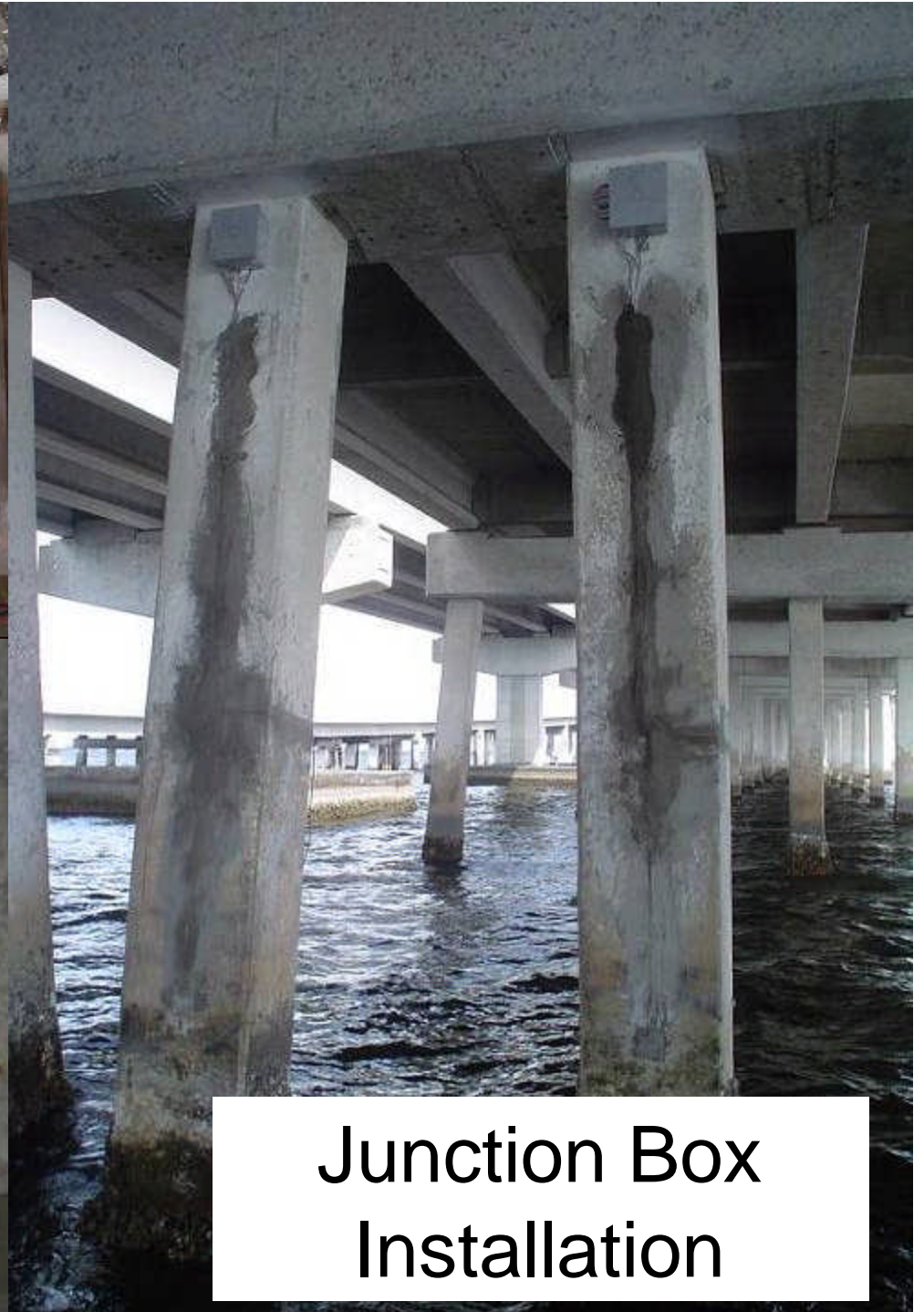
Allen Creek Bridge, Clearwater



Gandy Bridge, Tampa



Linear
Polarization



Junction Box
Installation

Measured Corrosion Rates in Controls vs Wrapped Piles

Pile	Date	Rate ($\mu\text{m}/\text{yr}$)
Control 91 cm above HWL	Nov 2004	8.39
	Jun 2005	6.77
	Aug 2007	9.46
Control 31 cm Below HWL	Nov 2004	49.6
	Jun 2005	20.48
	Aug 2007	38.48
Wrapped Pile 91 cm above HWL	Nov 2004	18.52
	Jun 2005	7.34
	July 2007	5.75
Wrapped Pile 31 cm Below HWL	Nov 2004	194.09
	Jun 2005	38.82
	July 2007	10.19

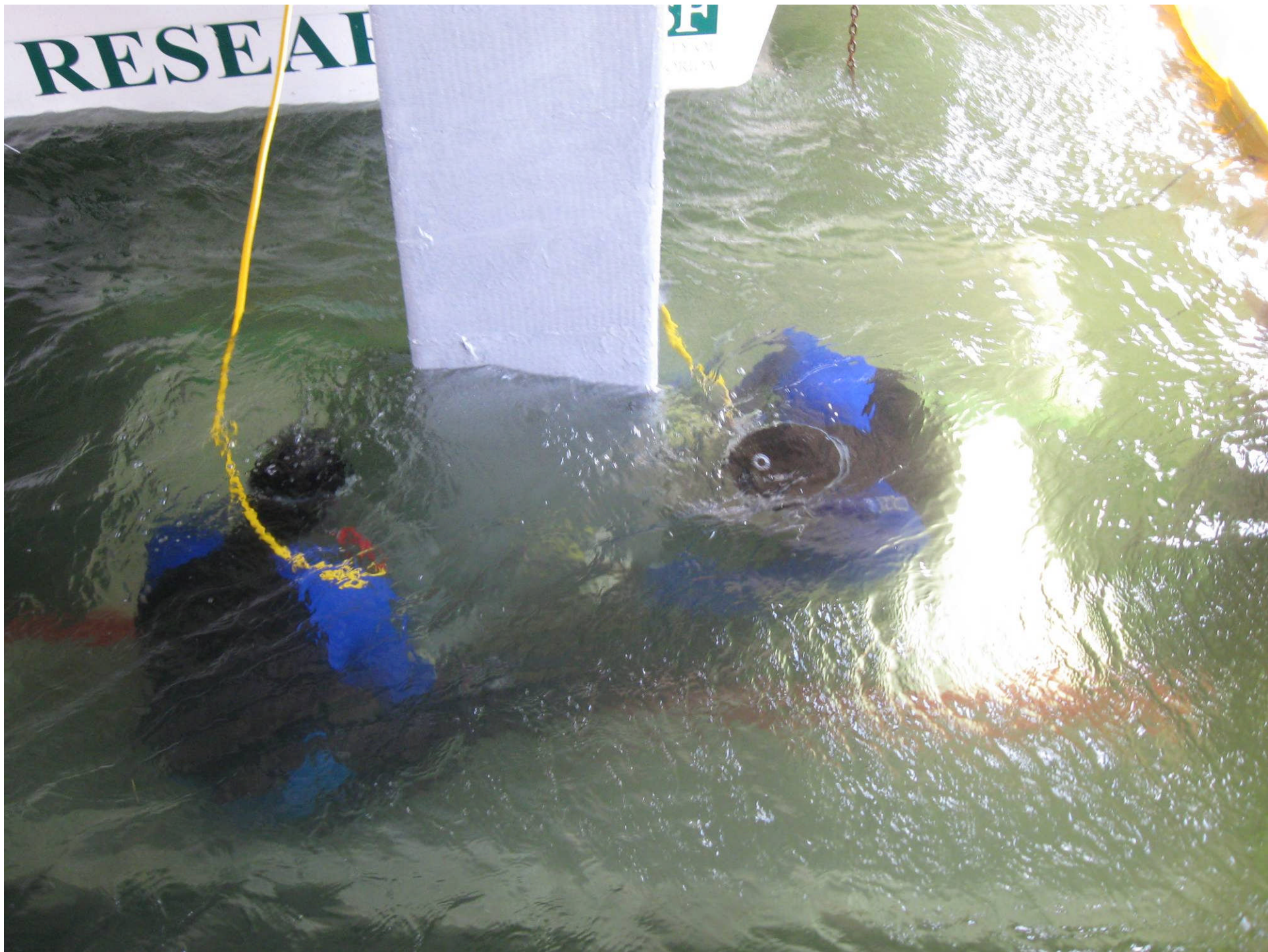
Latest Application

Grove Isle Bridge, Miami

January 2009







CP + Wrap + Pressure Bag



NCHRP-IDEA-128

Concluding Remarks

- 😊 FRP slows down the corrosion rate
- 😊 Performance of CFRP and GFRP are comparable
- 😊 Performance appears to be independent of number of layers
- 😊 Linear polarization correctly predicts trends

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